# A CONSIDERATION OF CURRENT CLINICAL THERMOMETRY

LESTER BLUM, M.D., STEPHEN SLATER, M.B.A.,
DEVAPRASAD REUBEN, R.R.A.,
AND PATRICIA ANVARIPOUR, R.N.

Departments of Surgery, Nursing, and Medical Records
The Mount Sinai Medical Center, CUNY
New York, New York

TRADITIONALLY, the presenting page of a hospital chart bears the graphic record of daily temperatures, pulse, and respiratory rates. In the past, observations were noted at four or six hour intervals. Latterly, the frequency of readings seems to have decreased, and a sparse recording of vital signs makes one wonder if this page of the chart has not become vestigial.

To satisfy this curiosity, a modest review of the manner in which the thermometer entered medical usage and examination of a series of charts, past and recent, may substantiate this pejorative impression.

Dr. Silas Weir Mitchell proposed that advances in medicine were due to the progressive application of quantitating devices to the care of the sick. He presented this concept in an address before the second congress of the Association of American Physicians and Surgeons in 1891.[1] A few years later, H.C. Bolton devoted a scholarly monograph to the oldest of these clinical tools, the thermometer.[2] Trustworthy evidence is presented that Galileo, who held the chair of mathematics at the University of Padua, exhibited his thermometer in his lectures of 1603. By 1611 Sanctorius Sanctorii, professor of the theory of medicine, was using it in fever cases. In 1646 an illustration of this instrument (Figure 1) as well as a device for timing the pulse, appeared in his commentaries on the first book of Avicenna.[3]

Bolton lists 1624 as the year that Jesuit Father Jean Laurechon baptised the new device with its permanent name. By 1694 Carlo Renaldini, then professor of mathematics at Padua, proposed the freezing and boiling points of water as limits for a scale of measurement. In 1714 Daniel Gabriel Fahrenheit introduced mercury into the column and advocated the

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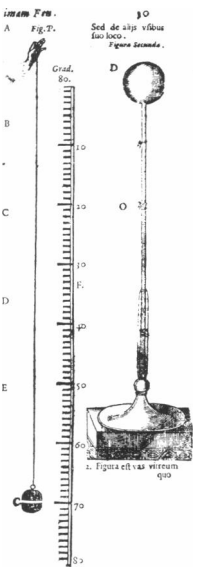

Sketch of thermometer with liquid reservoir at top and hand holding a weighted string next to a measure of 80 units for pulse (pulsilogium)[3]

method of mensuration named after him. In 1742 Anders Celsius, professor of astronomy at Upsala, used a scale of 100 units with ice at 100° and boiling water at 0°. Finally, one year later, Christin of Lyons reversed the scale of Celsius to establish the centigrade column which has been in use since. At the same time, in the 18th century, George Martine in England was conducting an extensive investigation into the construction and accuracy of thermometers as well as the normal range of body temperature in man, other mammals, and birds.[4]

The definitive monograph in clinical thermometry appeared a century later in 1868. Its author, Carl Reinhold August Wunderlich, had devoted a distinguished career to the study of body temperature in a host of diseases.[5] In the previous decade, Lord Kelvin, Helmholtz, and Clausius had established the laws of thermodynamics. Their work provided a physical basis for Wunderlich's clinical observations. He charted the fevers of the infectious diseases and set patterns of recording that have been followed ever since.

An example of his far-reaching influence is the unpublished manuscript

of Dr. Lucius Duncan Bulkley, preserved in the Rare Book Room of the New York Açademy of Medicine.[6] This comprises a detailed analysis of charts recording the experience at the New York Hospital in the treatment of 337 cases of all types of infectious disease over a span of three years prior to August 1869. It included 93 cases of typhoid fever, 23 of typhus, 21 of erysipelas, and 19 of phthisis.[7]

Since Dr. Bulkley's report, the spectrum of disease has changed dramatically. Gone are the epidemic fevers, rampant tuberculosis, long-draining osteomyelitis, late syphilis, poliomyelitis, empyemata, erysipelas, and puerperal fever. Surgical schedules have changed. Patients are older, procedures more complex, the critically ill are segregated in intensive care units surrounded by monitoring equipment far more sophisticated than any device for measuring body heat. In fact, when temperatures are recorded digitally instead of graphically, they can escape unnoticed in the welter of data.

The attitude of the physician toward the temperature record has changed over the years. No longer does he experience that surge of anxiety when he sees a spike in the curve. No longer is he so deeply troubled by the remittent fever persisting as the weeks slip by. He has an antibiotic armamentarium at hand and his diagnostic resources have been immeasureably expanded.

An evaluation of the current status of in-hospital thermometry calls for three lines of investigation. First, a review of charts from different time periods to discover the incidence of those diseases in which body temperature is an important parameter. If our vaunted control of infection is ever more effective, why the thermometer? Second, what is the opinion of the nursing staff in regard to temperature surveillance and the recording thereof? Finally, what is the cost-effectiveness of thermometry? This review does not include the recording of body temperature during anesthesia and special procedures.

Table I tabulates the numbers of patients in the Mount Sinai Hospital from 1967 until 1981 discharged with the diagnoses listed in the ordinate. These are compared with the total number of cases in order to arrive at some idea of the proportion of febrile disease in the patient spectrum.

Before analyzing these statistics, it should be noted that our record department adopted the nomenclature of the Hospital Adaptation of International Classification of Diseases advocated by the Commission on Professional and Hospital Activities in 1974. In 1979 the introduction of ICD-9-CM Nomenclature and Chart Diagnostic Review Function of the

TABLE I. INCIDENCE OF MOST COMMON FEBRILE DISEASES* : INPATIENTS TREATED DURING THE YEARS 1967-1981, MOUNT SINAI HOSPITAL, NEW YORK, NY

| *Includes primary and secondary diagnoses | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pneumonia | 534 | 582 | 358 | 390 | 467 | 425 | 337 | 321 | 615 | 539 | 629 | 665 | 694 | 716 | 670 |
| Urinary tract infection | 176 | 174 | 180 | 230 | 263 | 301 | 231 | 279 | 353 | 442 | 450 | 498 | 416 | 514 | 691 |
| Skin and subcutaneous abscess | 199 | 202 | 152 | 142 | 183 | 141 | 148 | 222 | 279 | 297 | 337 | 345 | 390 | 411 | 317 |
| Pyrexia of unknown origin | 126 | 105 | 101 | 86 | 98 | 86 | 82 | 139 | 134 | 167 | 394 | 423 | 513 | 624 | 412 |
| Phlebitis & thrombophlebitis | 37 | 30 | 136 | 160 | 166 | 180 | 215 | 235 | 239 | 272 | 237 | 231 | 172 | 184 | 200 |
| Acute appendicitis | 180 | 137 | 154 | 150 | 139 | 175 | 143 | 205 | 198 | 184 | 165 | 171 | 171 | 215 | 185 |
| Postoperative wound infection | 150 | 150 | 115 | 142 | 127 | 180 | 113 | 119 | 206 | 168 | 128 | 139 | 123 | 177 | 146 |
| Sepsis-septicemia | 88 | 112 | 90 | 141 | 109 | 120 | 89 | 77 | 161 | 172 | 128 | 155 | 155 | 217 | 253 |
| Acute pyelonephritis | 165 | 133 | 98 | 105 | 105 | 118 | 85 | 142 | 124 | 101 | 97 | 110 | 95 | 109 | 84 |
| Acute vaginitis-endometritis | 103 | 125 | 45 | 62 | 46 | 42 | 41 | 72 | 56 | 68 | 74 | 96 | 104 | 120 | 63 |
| Acute osteomyelitis | 46 | 41 | 38 | 43 | 40 | 38 | 40 | 33 | 55 | 46 | 46 | 56 | 65 | 86 | 84 |
| Bacterial endocarditis | 27 | 29 | 23 | 33 | 36 | 41 | 36 | 22 | 26 | 31 | 43 | 33 | 39 | 39 | 39 |
| Meningitis | 32 | 39 | 24 | 31 | 33 | 30 | 30 | 31 | 48 | 31 | 39 | 31 | 14 | 17 | 37 |
| Postpartum fever | 17 | 13 | 10 | 9 | 5 | 4 | 5 | 6 | 14 | 22 | 38 | 34 | 40 | 73 | 29 |
| Septic arthritis | 10 | 15 | 20 | 13 | 8 | 16 | 10 | 20 | 21 | 27 | 22 | 19 | 19 | 14 | 17 |
| Total | 1890 | 1887 | 1544 | 1737 | 1825 | 1897 | 1605 | 1923 | 2529 | 2567 | 2827 | 3006 | 3010 | 3516 | 3227 |
| Total number of discharges and percentage of febrile diseases | 32,752 (5.8) | 31,626 (6.0) | 26,717 (5.8) | 30,688 (5.7) | 30,598 (6.0) | 31,414 (6.0) | 29,712 (5.4) | 32,777 (5.9) | 35,063 (7.2) | 35,594 (7.2) | 36,347 (7.8) | 36,875 (8.2) | 37,875 (7.9) | 38,205 (9.2) | 38,678 (8.3) |

TABLE II. PATIENT CLASSIFICATION

| *Patient class* | *Hours of nursing care per diem* | *Percentile grouping* |
|---|---|---|
| I | 0 - 2 | 22% |
| II | 2 - 4 | 26% |
| III | 4 - 10 | 41% |
| IV | 10+ | 11% |

medical records department led to another alteration in the listing of discharge diagnoses. Emphasis was placed on secondary diagnoses both to amplify data collection and to expedite accounting and billing.

In view of the absence of any epidemics or recognized outbreaks of nosocomial infection, the apparent increases noted during the more recent years can be properly ascribed to a changed nomenclature.

Certainly, a statistician is not needed to conclude from Table I that there has not been any decrease in the volume of infectious diseases in a large medical center during recent years.

The second investigation was carried out by submitting a questionnaire to the supervisors of 43 nursing units. At the Mount Sinai Hospital a four-level patient classification system is used to plan nurse staffing. In Table II this method is outlined together with the average percentage of each class in the patient population. This latter is based on the average of one week picked at random.

The responses to the questionnaire were remarkably uniform. Two temperature readings per diem were typical of patients in Categories I and II. In Category III four readings per diem were required unless more were specifically ordered. Category IV patients were for the most part located in intensive care units where the regimen calls for six readings every 24 hours as a minimum.

The clinical supervisors estimated that approximately three minutes were needed to obtain an oral or rectal temperature. The sicker the patient, the greater time was needed because of restriction of movement due to debility or support equipment.

A perspective of the total nursing man-hours expended in thermometry can be obtained from Table III.

After tempertures are taken and logged by nurses, they are charted by unit clerks. Table IV shows the daily man-hours spent doing this function. Table V flows directly from Tables III and IV.

TABLE III. TOTAL NURSING MAN-HOURS EXPENDED IN THERMOMETRY

| *Patient classification* | *Average patients per diem* | *Average minutes per patient per diem thermometry* | *Total min. per diem* |
|---|---|---|---|
| I | 190 | 6 | 1,140 |
| II | 231 | 6 | 1,386 |
| III | 358 | 20 | 7,160 |
| IV | 91 | 30 | 2,730 |
| | | | 12,416 |
| | | Average hours/diem | 206.9 |

TABLE IV. UNIT CLERK MAN-HOURS CHARTING TEMPERATURES

| *Patient class* | *Average patients per diem* | *Average minutes charting per patient* | *Total minutes per diem* |
|---|---|---|---|
| I | 190 | 1.3 | 247 |
| II | 231 | 1.3 | 300 |
| III | 358 | 2.6 | 931 |
| IV | 1 | 3.9 | 355 |
| | | | 1,833 |
| | | Average hours/diem | 30.1 |

TABLE V. THERMOMETRY MANPOWER COST ANALYSIS

| *Activity* | *Manhours per diem* | *Average hourly rate (current-1982)* | *Daily cost* |
|---|---|---|---|
| Thermometry | 206.9 | $ 8.82* | $ 1,827 |
| Charting | 30.1 | $ 6.87 | 207 |
| | | Annual manpower cost | $742,410 |

*Registered nurses perform 75% of thermometry; nurse assistants do the remaining 25%.

## COMMENTARY

This study began as an inquiry into the need for the graphic vital signs sheet traditional in every hospital chart. As far as thermometry is concerned, it is evident that it is still an important parameter in the care of a large proportion of hospitalized patients. Its value is well worth its cost in

terms of manpower hours of nursing, despite the impressive figures obtained by an accounting analysis.

Twenty-five years ago Kory was annoyed by the persistent respiratory rate of 20 per minute appearing in four fifths of all charts in his hospital.[8] He studied a consecutive series of 57 patients reported at that rate in the cardiopulmonary laboratory, and discovered that only five breathed at that rate and the remainder varied from 11 to 30 per minute. It was clear to him that the physicians' lack of interest led to a rather casual attitude by the nursing staff. Kory estimated that taking the pulse and recording the respiratory rate took one minute of nursing time per diem. With 600,000 patients in hospitals in this country, making this observation once a day at the then (1957) going rate of $1.50 per hour led to a national cost of $5,500,000 for a dubious service.

Since almost all patients have an electrocardiographic tracing on admission, few should require repetitive counting of the pulse! Further, the impressive curves of pulse rate do not record its regularity, which is frequently of greater importance.

## SUMMARY

In febrile and critically ill patients the thermometer remains a clinically important instrument. It is well worth its place in terms of cost analysis. The graphic temperature sheet, which also records respiratory and pulse rates, should be replaced by a digital system more appropriate to the computer age.

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